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Patterns of Change in Approaches to Learning and Their Impact on Academic Performance among Medical Students: A Longitudinal Analysis

Giovanni Piumatti[a,b,c], Milena Abbiati[a], Margaret W. Gerbase[a], Anne Baroffio[a]

[a] Unit of Development and Research in Medical Education (UDREM), University of Geneva, Faculty of Medicine, Geneva, Switzerland, [b] Population Epidemiology Unit, Primary Care Division, Geneva University Hospitals, Geneva, Switzerland, [c] Faculty of BioMedicine, Università della Svizzera italiana, Lugano, Switzerland

Key words: deep approaches to learning; surface approaches to learning; structural equation modelling; medical students; academic performance

Contact: Giovanni Piumatti, giovanni.piumatti@unige.ch Unit of Development and Research in Medical Education (UDREM), Centre Médical Universitaire, 1, rue Michel Servet, CH-1211 Genève 4, Switzerland, Tel.: +41223795944

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Abstract

Theory: Several medical education studies suggest that deep approaches to learning (DA) are associated with better academic performance, whereas surface approaches (SA) are associated with worse academic performance. However, no study has assessed how these approaches change at the individual level during undergraduate medical training and how these trajectories contribute to academic performance. We assessed individual patterns of change in learning approaches throughout five years of medical training to determine whether and how DA and SA evolve during the curriculum and whether initial levels and rates of change predict performance in Year 5.

Hypotheses: We hypothesized that (1) medical students have a higher preference for DA in comparison with SA; (2) these preferences change along the medical curriculum; and (3) DA predicts better academic performance.

Method: Participants were 268 Geneva medical students (59% female) who completed the revised two-factor study process questionnaire in Years 1, 2, 3, and 5 of their 6-year curriculum. Student academic performance was registered in Year 5. Multivariate latent growth modeling was used to assess individual trajectories in learning approaches and test their associations with performance in Year 5.

Results: Medical students were inclined to use DA rather than SA. Nevertheless, from Year 2 onward their use of DA decreased while their use of SA increased. Students with higher initial levels of DA tended to have lower initial levels of SA. Moreover, increases in SA were significantly associated with decreases in DA. However, only initial levels of DA and non-repeater status in Year 1 were positive and significant predictors of academic performance in Year 5.

Conclusions: Although students tended to use DA rather than SA when entering medical school, their preferences for DA tended to decline throughout medical training while

increasing for SA. Learning approaches during early study years, characterized by engagement and meaningful learning, predicted later academic performance. DA should be promoted during the early years of medical studies to foster student learning and to improve academic performance.

Keywords: deep approaches to learning; surface approaches to learning; structural equation modeling; medical students; academic performance

Introduction

Approaches to learning are defined as strategies students adopt to gain new knowledge.[1, 2] Among medical students, these have been associated with academic performance,[3-6] clinical competence,[7, 8] clinical reasoning skills,[9] and approaches to work later in professional life.[10] Most studies have distinguished deep approaches (DA) and surface approaches (SA) to learning. The former is associated with an intrinsic interest in the content of the task and to higher performance results, and the latter is based on instrumental motivation that frames tasks as mere demands to be met, therefore, predicting lower performance results.[4, 6, 8, 11, 12] These two approaches may be modulated by the educational environment or by situational demands and can thus change over the course of an entire degree in higher education.[13-15] Moreover, they are not mutually exclusive *per se*: students adopting DA can still adopt SA and vice versa.[11, 16]

As stated in The Bologna Declaration,[17] successful learning and studying in higher education should engage students in DA. For medical education in particular, modern medicine requires doctors to master skills such as problem solving, deep thinking, and critical analysis in increasingly challenging scenarios, and medical schools are keen to sustain the acquisition of such competencies.[18-20] Moreover, several medical education studies have demonstrated that DA positively correlates with student academic performance across a wide range of assessment methods (including multiple-choice questions and oral tests), contrary to SA.[4, 7, 8] Thus, it is important to understand whether and how medical students modulate their approaches to learning throughout their training and whether these individual variations might affect their academic performance. This understanding could affect the choices of medical schools regarding efficient pedagogical strategies to promote deep learning among students.

Few studies have examined medical students' approaches to learning from a longitudinal quantitative perspective, and they have reported mixed findings. Positive changes

in DA across the second and third academic years in medical studies were reported by Vu et al.,[21] and Reid et al.[22] found a negative change in SA between the first and the final year. On the other hand, Chen et al.,[23] Iputo,[24] and Ova et al.[25] reported no changes in approaches to learning. As noted in a recent review of longitudinal studies on approaches to learning in higher education, including medical education,[13] heterogeneity in study results is related to major limitations of previous research, namely the adoption of short time-intervals to detect change and the lack of analysis at the individual level. Indeed, the absence of changes in learning approach at the group level does not exclude variation at the individual level;[26, 27] group-level analysis alone cannot fully capture the learning processes taking place among individual students.

Combining group- and individual-level analytical techniques to assess longitudinal changes in learning approach can be useful in medical education, where data often include heterogeneous groups of students.[28] A better understanding of how medical students modulate their approaches to learning throughout medical training could inform curriculum design; if initial levels and rates of change in DA and SA are associated with academic performance, this could indicate that more action is needed to sustain DA and could potentially inform when such effort should be focused during the curriculum.

The current study aimed to overcome the limitations of previous research by using multivariate latent growth modeling (MLGM) within the framework of structural equation modeling to examine individual changes in learning approach and their association with academic performance among medical students from the first to the fifth year of their studies.[29, 30] One of the aims of latent growth model analysis is to estimate the range of individual differences in change over time, without focusing solely on changes in observed group means.[31] Specifically, this methodological approach describes a single individual's developmental trajectory in terms of its initial level and rate of change over time and captures

individual longitudinal differences in these trajectories.[32] The three main advantages of using MLGM are:[31] (1) the ability to estimate both initial levels and rates of change in approaches to learning at the individual level; (2) the ability to test how DA and SA are longitudinally related; and (3) the ability to assess how initial levels and rates of change in learning approaches predict student academic performance. By modeling approaches to learning in terms of individual trajectories, we can not only highlight whether changes occur within students across time, we can also test whether these changes are substantial enough to explain individual differences in academic performance or whether initial levels in approaches to learning play a more determinant role. Our main research questions can thus be summarized as follows: (1) Do individual medical students' approaches to learning, operationalized as DA and SA, change across study years? and (2) Do individual trajectories in learning approach predict student performance?

Despite the exploratory nature of this study, some hypotheses could be formulated based on two main assumptions from the literature. First, as stated earlier in this introduction, learning approaches are not static over time, especially when observing the entire course of higher education.[13-15] Second, medical students on average tend to prefer DA rather than SA,[3, 33, 34] a tendency observed also in other samples of university students.[35, 36] Accordingly, we hypothesized that (1) medical students have a higher preference for DA in comparison with SA; (2) these preferences change along the medical curriculum; and (3) DA predicts better academic performance.

Methods

Educational Context

This study was conducted at the Faculty of Medicine of the University of Geneva, Switzerland. The undergraduate curriculum is divided into a pre-selection year (Year 1), two pre-clinical years (Years 2 and 3), two clinical years (Years 4 and 5), and one elective year

(Year 6). The curriculum is designed to provide a student-centered and integrated approach to student acquisition of theoretical knowledge and clinical competencies. Specifically, Year 1 is organized into multidisciplinary integrated modules essentially delivered via large-group lectures. At the end of this pre-selection academic year, students are assessed by multiple-choice-questions (MCQs) and admitted to the second year based on their performance. Those who fail to be admitted to the second year are allowed to repeat the first year. If they fail again, they are definitely excluded.

The preclinical curriculum in Years 2 and 3 is organized into multidisciplinary thematic teaching units taught by problem-based learning in small groups combined with a few integrated lectures, practical sessions, and seminars of clinical skills training and community dimension. The knowledge and skills acquired during the teaching units are assessed by MCQs, multidisciplinary vignette questions, practical examinations and objective-structured-clinical-examination (OSCE).

Across Years 4 and 5, students rotate through clinical clerkships in surgery, paediatrics, internal and primary care medicine, psychiatry, obstetrics and gynaecology, neurology and neurosurgery, emergency and intensive care medicine, dermatology, ophthalmology, and otolaryngology. Within these rotations, they are exposed two days a week to selected patient problems by case-based clinical reasoning tutorials and assigned to a ward unit three days a week where they admit patients and are observed by supervisors. During this same period, students benefit from learning activities (i.e., self-learning and seminars) across transversal disciplines (i.e., pathology, radiology, clinical pharmacology, forensic medicine, and medical ethics). Clinical reasoning skills, professionalism, and clinical interactions are evaluated through regular ward formative evaluations, summative oral or written case analyses and simulated patient encounters. For both pre-clinical and clinical

years, success rate is about 98%. A licensing exam at the end of Year 6 completes undergraduate medical training. Its success rate is on average 97%.

Procedures and Sample

Participants were medical students enrolled in the pre-selection/first academic year at the University of Geneva in 2011, 2012, or 2013. Overall, data collection took place in four periods: pre-selection/first academic year (Year 1), beginning of pre-clinical training (Year 2), end of pre-clinical training (Year 3), and end of clinical training (Year 5). Longitudinal selection criteria required students to be present at least two more times after Year 1 across the three waves of data collection in Years 2, 3 and 5.

As a result, the analyses included 268 students (mean age = 20.85 years, SD = 1.94, range = 18–38, 59% females), 197 (74%) of which participated in all data collections and 71 (26%) participated in three out of four data collections (see Appendix S1 for further details on sample selection). This longitudinal sample included 72% of the total number of students who were successfully admitted to Year 2 between 2012 and 2013. In terms of gender composition, the current sample was representative of the entire population of successful students transitioning from Year 1 to Year 2 between 2012 and 2014. Moreover, participating students did not significantly differ from their non-participating peers in terms of academic performance at the end of Year 1. Among these 268 participants, 146 (54%) were ‘repeaters,’ namely students who had repeated Year 1 before being admitted to Year 2. Repeaters were on average significantly older than their non-repeater peers (p=0.004), while we observed no gender differences between these two groups.

All students signed an informed consent describing the voluntary condition of the study and the confidentiality of their responses. Data collection was conducted using paper-and-pencil self-administered questionnaires. The Chair of the Cantonal Commission for Ethical Research (CCER) designated the current study as exempted from formal review.

Measures

Approaches to Learning. The revised two-factor study process questionnaire (R2-SPQ)[37] was used to measure student approaches to learning across four assessments (in Years 1, 2, 3, and 5). Previous studies have reported significant associations between medical students' academic performance and their approaches to learning as measured by the R2-SPQ.[23, 38] This instrument consists of 20 items scored on a 5-point Likert scale (from 1 = *this item is never or only rarely true of me* to 5 = *this item is always or almost always true of me*), with 10 items measuring DA and 10 items measuring SA. Items tapping into dimensions of DA describe learning as an enjoyable activity driven by internal motivations and commitment to understand and construct meaning from the learning content (e.g., "I find that at times studying gives me a feeling of deep personal satisfaction" and "I find that I have to do enough work on a topic so that I can form my own conclusions before I am satisfied"). Conversely, items referring to SA depict learning as a process involving little understanding and requiring the minimum possible effort (e.g., "My aim is to pass the course while doing as little work as possible" and "I learn some things by rote, going over and over them until I know them by heart even if I do not understand them"). We calculated total scores for DA and SA by summing up the scores of all the items grouped under each dimension. Cronbach's α reliability scores ranged from 0.73 to 0.84 across assessments for DA and from 0.65 to 0.78 for SA. Previous research[37] reported similar reliability results for the R2-SPQ. As it was not available in French, the current study adopted a French version of the R2-SPQ created by translating into French the previously validated English items and back-translating them into English by two independent reviewers for quality control.[39]

Academic performance. For the current study, students' last self-report of approaches to learning took place during the second semester of Year 5. Accordingly, in order to model approaches to learning as predictors of academic performance, we selected all exam scores

and grades in Year 5 registered after this last self-reported assessment. As a result, we focused on four computer-based assessments consisting of MCQ (ophthalmology, emergency and intensive care medicine, pathology, and radiology), and four oral tests (neurology and neurosurgery, otolaryngology, forensic medicine and medical ethics, and dermatology). The assessments consisting of simulated patient encounters were excluded because they occurred prior to students' Year 5 self-reports of learning approach. Students received a score between 0 and 100 on every MCQ assessment and a grade between 0 and 6 on every oral test. An overall performance score was obtained by standardizing MCQ assessment scores and oral test grades (for a mean of 0 and a standard deviation of 1) and averaging the obtained standardized scores across the 8 examinations.[40] **Table A1** in the Supplemental Appendix reports the correlations between the standardized scores of all eight examinations.

Covariates. Age (in years), gender (0 = *males*, 1 = *females*) and repeater status (0 = *non-repeater*, 1 = *repeater*) were included as covariates in the analyses because previous research indicates they are significant correlates of learning approach and significant predictors of academic performance among medical students.[3, 41] In particular, students repeating academic years after failing are more likely to have significantly worse academic performance than their non-repeater peers.[42, 43]

Data Analyses

A detailed explanation of the analytical procedures adopted in the current study is provided in the Supplemental Appendix. We preliminarily checked data for missing values and violations of the normality assumption. Longitudinal analyses were then divided into three steps. To answer our first research question about whether individual medical students' approaches to learning change across study years, we used Latent Growth Modeling (LGM)[30, 32] to estimate the intercept (i.e., initial level) and slope (i.e., rate of change) factors of DA and SA across assessments (from Year 1 to Year 5). Within LGM, the intercept is a constant for

any participant across time and represents the starting point of every individual trajectory. On the other hand, the slope represents the rate of change or growth and, thus, may be positive or negative depending on whether individuals exhibit an increasing or a decreasing trend across time. Differences in approaches to learning between consecutive years were further tested by means of paired-sample t-tests with post hoc Bonferroni adjustment. To better understand whether and how DA and SA simultaneously change across time, MLGM examined the dynamic relations between initial levels and rates of change of DA and SA. **Figure 1** depicts the structural path diagram tested by MLGM at this stage. Finally, to answer our second research question, MLGM tested both initial levels and rates of change of DA and SA as predictors of student academic performance in Year 5 while further controlling for the effect of age, gender and repeater status in Year 1. All analyses were performed in Stata 15 (StataCorp. 2015. Stata Statistical Software: Release 15. College Station, TX: StataCorp LP).

Results

Preliminary analyses

Students from the three consecutive data collection groups (i.e., baseline in 2011, 2012 or 2013) did not differ in terms of approaches to learning, overall academic performance in Year 5, age, or gender composition at any time point (see **Table A2** in the Supplemental Appendix). These results support the decision to combine students from different consecutive surveys in the current analyses.

The missing data rate ranged from 0 to 18.7% across all variables included in the analyses. According to previous research,[44] these percentages are still considered acceptable to test for possible systematic mechanisms behind missing patterns and to evaluate strategies to deal with the problem. Little's test for data missing completely at random (MCAR) applied to DA and SA scores across assessments was not significant ($p = 0.384$), indicating that the data were MCAR. Absolute values of skewness and kurtosis ranged from 0.03 to 0.43 and

from 2.58 to 3.40, respectively, suggesting that longitudinal scores for approaches to learning were reasonably normally distributed.[31] Based on these preliminary results, we applied the full information maximum likelihood estimation method in LGM and MLGM estimations to deal with missing values.

Individual longitudinal changes in approaches to learning

From **Table A3** in the Supplemental Appendix, the differences in χ^2 between nested models indicated that a non-linear growth model provided the best fit to the data for both DA and SA. Standardized intercept and slope means were significantly different from zero for DA (intercept mean = 7.40, SE = 0.42, $p < 0.001$; slope mean = -1.10, SE = 0.24, $p < 0.001$) and SA (intercept mean = 5.74, SE = 0.04, $p < 0.001$; slope mean = 0.81, SE = 0.27, $p = 0.002$), indicating that, overall, students decreased in terms of DA and increased in terms of SA. The correlation between the intercept and slope factors was not significant for either DA or SA, meaning that students' initial levels in approaches to learning were not associated with how they varied across years. The results of the paired sample t-tests (see **Table 1**) indicated that approaches to learning remained rather stable from Year 1 to Year 2. On the other hand, during pre-clinical years (from the beginning of Year 2 to the end of Year 3), students decreased their use of DA ($p < 0.001$) and increased their use of SA ($p < 0.001$). Similarly, during the clinical years (from the end of Year 3 to the end of Year 5), DA continued to decline ($p < 0.001$), whereas SA remained stable.

The two nested LGM models were then combined using MLGM in order to estimate correlations between DA and SA intercepts and slopes (see **Figure 1**). This model yielded an acceptable fit [$\chi^2(18) = 52.90$, $p < 0.001$; CFI = 0.957, TLI = 0.932, RMSEA = 0.085]. **Figure 2** shows the longitudinal expected scores in DA and SA based on MLGM analyses. The standardized intercept and slope means were again significantly different from zero for DA (intercept mean = 7.46, SE = 0.43, $p < 0.001$; slope mean = –1.13, SE = 0.23, $p < 0.001$) and

SA (intercept mean = 5.64, SE = 0.37, $p < 0.001$; slope mean = 0.90, SE = 0.28, $p = 0.001$). The co-variance between intercepts ($r = –0.53$, $p < 0.001$) and between slopes ($r = –0.54$, $p = 0.019$) of DA and SA was significant. This means that students with higher initial levels in DA tended to report lower initial levels for SA and vice versa. Likewise, the greater the increase in SA, the greater the decrease in DA, and vice versa.

Approaches to learning as predictors of academic performance

In the last step of the analysis, we expanded upon MLGM by specifying both initial levels and rates of change of DA and SA as predictors of student academic performance in Year 5, alongside the effect of age, gender, and repeater status in Year 1 as time-invariant covariates (see **Figure 3** for a graphical representation of the structural path diagram for this last model). **Table A4** in the Supplemental Appendix shows the correlations between all variables included in this last model. Only significant covariances between independent variables were specified in the model. This model yielded an acceptable fit [$\chi^2(50) = 98.83$, $p < 0.001$; CFI = 0.943, TLI = 0.928, RMSEA = 0.060]. **Table 2** reports the standardized model estimates and significance levels. Students with higher initial levels of DA were more likely to have better academic performance results in Year 5 ($p < 0.023$). Moreover, students who entered the study as repeaters in Year 1 were more likely to have worse academic performance in Year 5 compared to their non-repeater peers ($p = 0.004$). Gender (i.e., female) positively correlated with the rate of change for DA ($p = 0.013$) and negatively correlated with the initial level for SA ($p = 0.005$). In sum, despite significant decreases and increases in DA and SA, respectively, across study years, only each student's initial level of DA appeared as significant and positive predictors of academic performance.

Discussion

To the best of our knowledge, this is the first study to test individual rates of change in

learning approach among medical students, with further examination of how DA and SA interact over time and whether learning approach trajectories predict academic performance. We found the following: (1) although medical students tended to prefer DA over SA, they decreased their use of DA and increased their use of SA during medical training; and (2) higher initial levels of DA predicted better performance results during clinical training. These findings are aligned with our initial hypotheses according to which (1) medical students have a higher preference for DA in comparison with SA; (2) these preferences change along the medical curriculum; and (3) DA predicts better academic performance.

Although this study confirms that, on average, medical students were more inclined to use DA rather than SA,[3, 33] our results are discordant with previous findings indicating either no longitudinal changes in learning approach among medical students[23-25] or positive and negative changes in DA[21] and SA, respectively.[22] However, past research has been limited to analyses at the group level. The observation that DA declined throughout the course of medical education is aligned with results from other cohorts of non-medical students.[45-48] Similarly, previous studies have found that university students tend to increase in SA across their academic studies.[46-51]

Consistent with previous research,[3, 4, 7, 8, 52] the current study confirmed that medical student use of DA can positively predict academic performance. We also showed that DA rather than SA was associated with performance outcomes during higher education.[6, 53, 54] In addition, despite the significant observed changes in DA and SA, these trajectories did not further differentiate students in terms of academic performance during the clinical years. This suggests that students' high engagement and meaningful learning at the onset of medical training is sufficiently important to predict long-term academic performance, despite an overall tendency for DA to decline across time. That SA was not found to be a significant

negative predictor of academic performance may reflect the finding that medical students in the current sample tended to prefer DA rather than SA when entering university.

These results have important practical implications for designing pedagogical strategies to sustain optimal learning. Because medical schools are keen to develop interventions that can maximize impact on tangible results, they must target students on the basis of specific individual attributes. Targeting undergraduate medical students with lower DA levels at entry may increase the effectiveness of focused interventions. Indeed, as pointed out by others,[34, 43, 55] approaches to learning can be taught and promoted by enhancing students' internal motivation[41] or by reinforcing their social identity.[56] In that sense, encouraging students to reflect on these aspects and on their learning process might prove to be an efficient approach.[57] Moreover, our results suggest that repeaters should be regarded as a specifically at-risk category in terms of academic performance, and they should be given the opportunity to seek help and support as early as possible during the undergraduate years.[43, 58] Nevertheless, it is important to underline that learning approaches in the current sample did not differ as a function of repeater status. Accordingly, remedial interventions targeting repeater medical students may focus on students' individual characteristics other than learning approach.[59, 60]

A novel finding of this study was the longitudinal interaction between DA and SA: as medical students increased their preference for SA, they decreased their preference for DA. Changes in approaches to learning for medical students can be interpreted through the lens of the continuum model, according to which students may switch between alternative approaches to learning in response to the demand of assessment tasks.[61] Moreover, previous studies have also underlined that it is difficult to maintain both types of approaches simultaneously.[62, 63] The variation in approach to learning observed here also could be interpreted in relation to variation in educational context across academic years, particularly

how students perceive this context; more than educational context itself, how it is perceived affects the use of learning approaches.[64] In the present study, decline in DA was particularly evident during clinical training, which combines structured case-based teaching and more experiential and situated learning at the bedside. This context contrasts with that of the structured learning environment in the pre-clinical years.

Clinical training may place greater pressure on students, who are confronted with developing clinical knowledge and reasoning in various specialties via rotations in hospital units. In particular, previous studies have highlighted that the clinical years are more stressful than pre-clinical years,[65-67] and stress and anxiety have important effects on medical student learning, resulting in lower DA and higher SA.[68] Although clinical skills training starts during Year 2 in our medical school, students might still feel unprepared and anxious about starting their clerkship,[65-67] which could worsen their perception of the educational context and decrease their use of DA. Future interventions and strategies in medical education aimed at sustaining DA should thus take place already during the early years of study and throughout the clinical years to prepare and support students for a more seamless transition to clinical training.

Some limitations of this research should be acknowledged to better address directions for future research. First, this was a single-institution study; therefore, our results may not necessarily generalize beyond our context. Second, although the "deep/surface approach to learning" framework is widely adopted in medical education research,[4, 8, 11, 12] alternative models may be used to describe approaches to learning[69, 70] and to test their longitudinal change. For example, we may further differentiate between deep, surface, and strategic approaches to learning, the latter approach aimed in particular at obtaining the highest grades.[71] Third, predictors other than learning approach may explain academic performance in

medical students. Future studies aimed at replicating our current model should therefore include a wider range of psychological correlates of performance.[6, 72]

On a related note, although beyond the scope of the current study, several factors not included here may explain the observed decline in DA and the increase in SA. As noted above, students' perceptions of their teaching–learning environment can impact their approaches to learning,[73, 74] and these perceptions might worsen during the transition to clinical training. Further, approaches to learning may also be influenced by student workload and motivation,[41, 75, 76] as well as by the type of assessment.[77] Future research adopting focus groups could be used to explore these factors and identify the various reasons for changes in students' learning approach. Finally, future studies also should examine whether a decline in DA coupled with an increase in SA relates to worse outcomes across different types of assessments, including clinical reasoning, as previous cross-sectional research has demonstrated.[8, 9, 22] Further exploring the heterogeneity in medical students' learning approach trajectories may help identify sub-groups of students with similar longitudinal trends and provide additional insights into changes in learning approach relative to specific individual characteristics and outcomes.

Despite these limitations and the possibilities to further elaborate the longitudinal model of approaches to learning presented here, this study sheds light on how medical students change their approaches to learning across their studies and how such individual trajectories predict academic performance. In particular, these results highlight the importance of examining this issue from an individual perspective, which may further help to support medical education pedagogical strategies that favour deep learning and successful studying.

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